Automated Carotid Endarterectomy Surgery using a low cost remodeled industrial robotic arm

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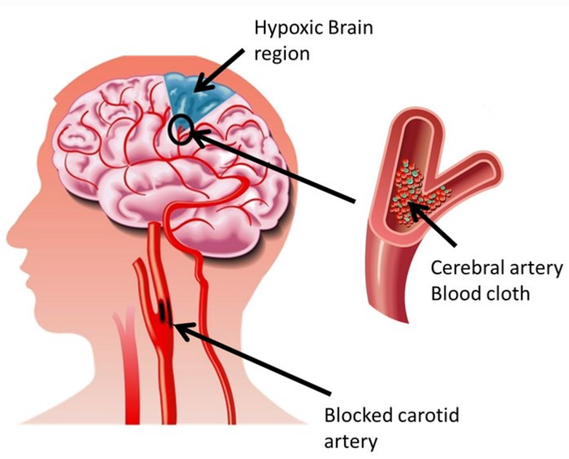
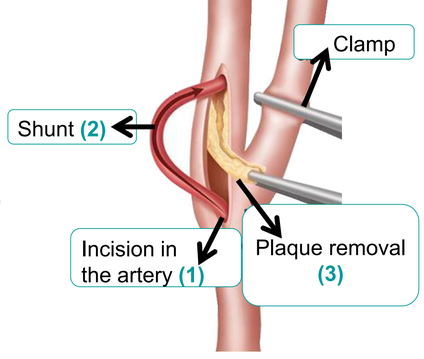
Introduction

- The carotid arteries are responsible of suppling the brain with oxygenated blood.
- When fatty deposits known as plaque are accumulated in these arteries the blood flow and therefore the oxygen transport is restricted
- Possible outcomes of this include a stroke, or a transient ischaemic attack.



Surgical procedure

1. An incision is made in the neck at the location of the targeted artery.
2. The blood is diverted to the brain by inserting a 'Shunt' into the artery.
3. The plaque is removed from the artery.
4. The shunt is removed the artery and the main incision are sealed.



Motivation

- Every year over 2 million new strokes occur in the US and the Europe, making stroke the third leading cause of death and a principal cause of long-term disability
- Worldwide, 15 million people annually suffer a stroke - of these, 5 million die (equivalent to 10% of worldwide deaths) and another 5 million are left permanently disabled [1].
- Atherosclerotic disease accounts for approximately 25% of ischaemic strokes caused mainly by embolic events from carotid artery bifurcation or the aortic arch [2].
- In the UK, every year there are about 152,000 strokes and currently about 1.2 million people in the UK suffer from the after effects [3].

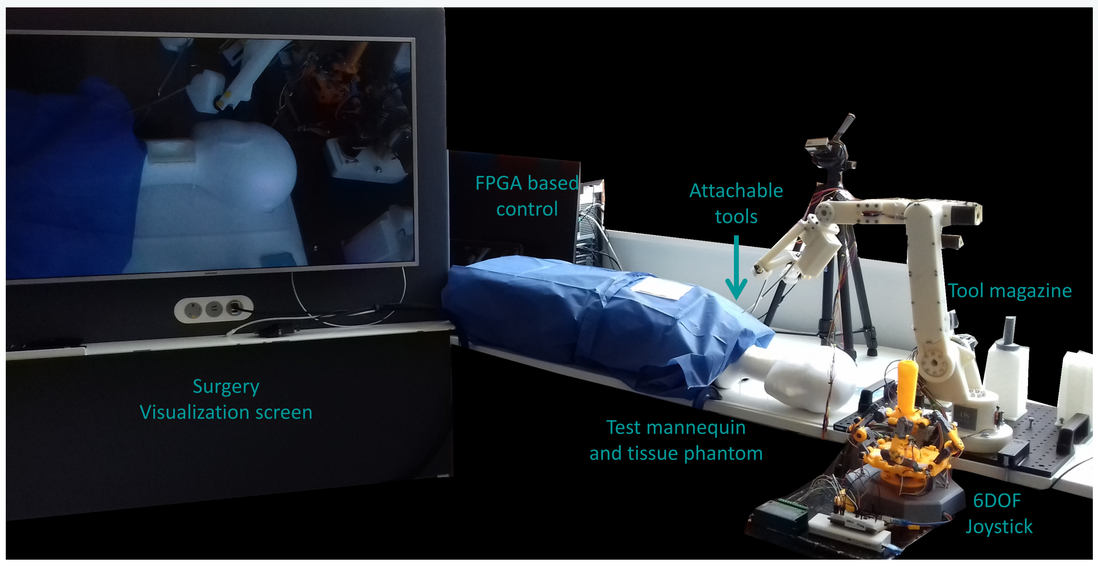
References

[1] Western Vascular institute, "Carotid Artery Desease," http://www.vascular.ie/carotid

[2] Emelia J. Benjamin et al, "Heart Disease and Stroke Statistics—2018 Update: A Report From the American Heart Association" Circulation, Vol. 137, No. 12 (2018).

[3]British heart foundation, "Focus on: Stroke and carotid artery disease," https://www.bhf.org.uk/informationsupport/heart-matters-magazine/medical/stroke-and-carotid-artery-disease.

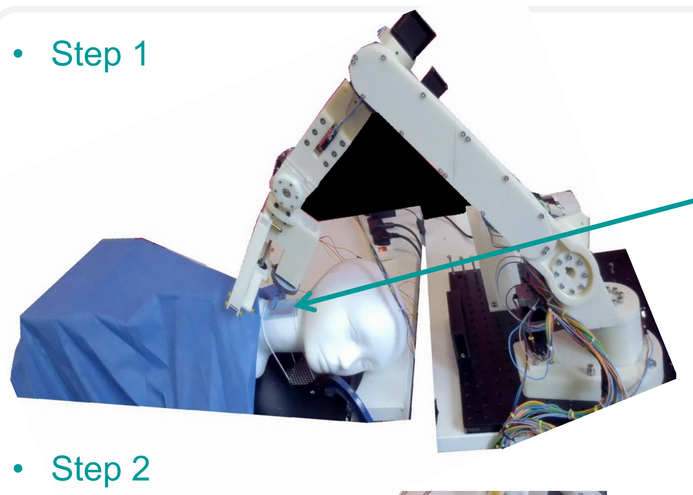
Robot Design and implementation



- We have redesigned a 6 DOF industrial based robot to perform carotid endarterectomy surgery as the operation site is easily accessible.
- No complex/flexible manoeuvres are required to reach the area.
- There are no 'blind spots' where additional sensors could be potentially added.

Carotid endarterectomy simulation tests

- Step 1



Neck incision using scalpel and phantom model

- Step 2

Plaque removal in phantom model using forceps

Conclusions

- An industrial based 6 DOF robotic arm has been modified, built and tested for performing carotid endarterectomy surgery using a phantom mannequin model.
- The robotic platform is equipped with the three main tools required for performing the surgical procedure (scalpel forceps and scissors). These are automatically selected from a tool magazine.
- The surgical procedure can be performed autonomously (preprogramed commands), or through the developed joystick.
- Initial tests for performing the neck incision and plaque removal demonstrate the potential of this platform to further be developed to carry out the full surgical procedure.